sensitiveness of the galvanometer was exactly the same in all the observations, still it was probably not greatly different.

Observations of the heat of the stars, if strictly comparable, might be of value, in connexion with the spectra of their light, to help us to determine the condition of the matter from which the light was emitted in different stars.

I hope at a future time to resume this inquiry with a larger telescope, and to obtain some approximate value of the quantity of heat received at the earth from the brighter stars.

IV. "On the Fracture of Brittle and Viscous Solids by 'Shearing.'" By Sir W. Thomson, F.R.S. Received January 2, 1869.

On recently visiting Mr. Kirkaldy's testing works, the Grove, Southwark, I was much struck with the appearances presented by some specimens of iron and steel round bars which had been broken by torsion. Some of them were broken right across, as nearly as may be in a plane perpendicular to the axis of the bar. On examining these I perceived that they had all yielded through a great degree to distortion before having broken. I therefore looked for bars of hardened steel which had been tested similarly, and found many beautiful specimens in Mr. Kirkaldy's museum. These, without exception, showed complicated surfaces of fracture, which were such as to demonstrate, as part of the whole effect in each case, a spiral fissure round the circumference of the cylinder at an angle of about 45° to the length. This is just what is to be expected when we consider that if A B D C (fig. 1) represent an infinitesimal square on the surface of a round bar with its sides A C and B D parallel to the axis of the cylinder, before torsion, and A B D′ C′ the figure into which this square becomes distorted just before rupture, the diagonal A D has become elongated to the length A D′, and the diagonal B C has become contracted to the length B C′, and that therefore there must be maximum tension every-

Fig, 1.

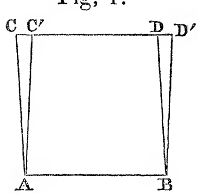
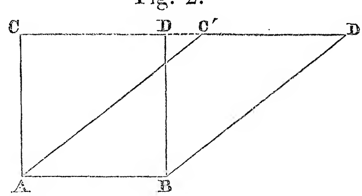


Fig. 2.



where, across the spiral of which B C′ is an infinitely short portion. But the specimens are remarkable as showing in softer or more viscous solids a tendency to break parallel to the surfaces of "shearing" A B, C D, rather than in surfaces inclined to these at an angle of 45°. Through the kindness of Mr. Kirkaldy, his specimens of both kinds are now exhibited

to the Royal Society. On a smaller scale I have made experiments on round bars of brittle sealing-wax, hardened steel, similar steel tempered to various degrees of softness, brass, copper, lead.

Sealing-wax and hard steel bars exhibited the spiral fracture. All the other bars, without exception, broke as Mr. Kirkaldy's soft steel bars, right across, in a plane perpendicular to the axis of the bar. These experiments were conducted by Mr. Walter Deed and Mr. Adam Logan in the Physical Laboratory of the University of Glasgow; and specimens of the bars exhibiting the two kinds of fracture are sent to the Royal Society along with this statement. I also send photographs exhibiting the spiral fracture of a hard steel cylinder, and the "shearing" fracture of a lead cylinder by torsion.

These experiments demonstrate that continued "shearing" parallel to one set of planes, of a viscous solid, developes in it a tendency to break more easily parallel to these planes than in other directions, or that a viscous solid, at first isotropic, acquires "cleavage-planes" parallel to the planes of shearing. Thus, if C D and A B (fig. 2) represent in section two sides of a cube of a viscous solid, and if, by "shearing" parallel to these planes, C D be brought to the position C′ D′, relatively to A B supposed to remain at rest, and if this process be continued until the material breaks, it breaks parallel to A B and C′ D′.

The appearances presented by the specimens in Mr. Kirkaldy's museum attracted my attention by their bearing on an old controversy regarding Forbes's theory of glaciers. Forbes had maintained that the continued shearing motion which his observations had proved in glaciers, must tend to tear them by fissures parallel to the surfaces of "shearing." The correctness of this view for a viscous solid mass, such as snow becoming kneaded into a glacier, or the substance of a formed glacier as it works its way down a valley, or a mass of débris of glacier-ice, reforming as a glacier after disintegration by an obstacle, seems strongly confirmed by the experiments on the softer metals described above. Hopkins had argued against this view, that, according to the theory of elastic solids, as stated above, and represented by the first diagram, the fracture ought to be at an angle of 45° to the surfaces of "shearing." There can be no doubt of the truth of Hopkins's principle *for an isotropic elastic solid, so brittle as to break by shearing before it has become distorted through more than a very small angle*; and it is illustrated in the experiments on brittle sealing-wax and hardened steel which I have described. The various specimens of fractured elastic solids now exhibited to the Society may be looked upon with some interest, if only as illustrating the correctness of each of the two seemingly discrepant propositions of those two distinguished men.